PHYS 782            Condensed Matter Physics            Spring 2011

# 22127 (3 credits)

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Meetings:  TTh 9:00-10:30 a.m., SE 221  Office Hours:  To be arranged

Bulletin Description:  An introduction to the field of soft condensed matter, focusing on colloids, polymers, liquid crystals, surfactants, membranes, and other biological systems. Topics will include characterization of soft materials, interparticle interactions, structure, equilibrium phase behavior, nonequilibrium properties, and practical applications.

Preparation:  Advanced knowledge of mechanics, electrostatics, thermodynamics, and statistical mechanics. Experience with numerical methods and computer programming.

Student Responsibilities:  Attend all lectures. Read assigned material in advance. Come prepared for discussion. Be curious; ask questions. Complete assignments on time.

Objectives:  • Develop conceptual understanding and practical expertise in modern theoretical and computational methods applied to soft matter systems.

• Gain an appreciation for the remarkable physical properties and industrial applications of soft materials.

Topics:  Colloids, polymers, liquid crystals, and amphiphiles (see p. 2).


Evaluation:  Homework  30%  All assignments and the research project
Research Project  20%  must be completed to pass the course.
Exams (2)  40%
Participation  10%

Lateness:  Late homework will be accepted with a 20% penalty/day until next class.

Grading:  A:  ≥ 85%, B: 70-84.9%, C: 60-69.9%, F: < 60%

All work in this course must be completed in a manner consistent with NDSU University Senate Policy, section 335: Code of Academic Responsibility and Conduct (http://www.ndsu.nodak.edu/policy/335.htm).

Any students with special needs are encouraged to contact the instructor promptly to make appropriate arrangements.
## Topics

### I. INTRODUCTION
- Defining characteristics of soft condensed matter
- States of matter, self-assembly, and phase transitions
- Applications of soft materials
- Review of statistical physics

### II. COLLOIDS
- Brownian motion
- Interparticle interactions and stabilization
- Effective interactions and DLVO theory
- Structure and phase behavior
- Nanoparticles
- Dynamics: Aggregation, rheology

### Applications
- Paints and inks
- Food colloids (e.g., milk)
- Sedimentation and flotation
- Photonic materials
- Quantum dots
- Drug delivery

### III. POLYMERS
- Fractal nature of polymers
- Statistical mechanics of chain molecules
- Polymer solutions, melts, and thin films
- Block copolymers
- Phase separation, glass transition

### Applications
- Rubbers and plastics
- Food polymers
- Biopolymers (proteins, DNA, actin)
- Viscoelastic fluids
- Synthetic materials

### IV. AMPHIPHILES
- Micelles, bilayers, and vesicles
- Langmuir monolayers
- Microemulsions
- Membranes, carbon nanotubes

### Applications
- Soaps and detergents
- Thin films
- Foams
- Biological cells

### V. LIQUID CRYSTALS
- Classification by symmetry
- Nematics and cholesterics
- Smectics and columnar phases
- Phase transitions

### Applications
- Display devices (LCD)
- Heat sensors